European Journal of Clinical Nutrition (2014) **68**, 1

www.nature.com/ejcn

EDITORIAL

Indirect calorimetry: a case for improved standard operating procedures

European Journal of Clinical Nutrition (2014) **68,** 1; doi:10.1038/ejcn.2013.211

In the present era of plug-and-play some scientists may be misled into believing that displayed or printed results are rigorously correct, provided that the instrument has been calibrated according to the manufacturers' instructions. An article published at the beginning of the year by Schadewaldt *et al.*[1] re-highlights the errors of such an assumption. They compared two commercially produced indirect calorimeters (ICs), the Vmax Encore 29n (Sensor Medics Corp., Homestead, FL, USA) and the Deltatrac MBM-100 (Datex-Ohmeda, a subsidiary of GE Healthcare Ltd, USA). Although the latter is no longer commercially available, it was, and still is, widely used for metabolic measurements due to its compact size, rapid calibration and ease of use and was invariably considered to be the 'Gold Standard' for measuring resting energy expenditure against which other commercially available ICs were compared. In spite of this, Schadewaldt and others have observed shortcomings in the results produced by the Deltatrac MBM[1–3] and the Vmax Encore 29n,[1] whether they be used for the measurement of resting energy expenditure and/or the respiratory quotient and substrate utilization. To improve the accuracy of a given IC, and potentially compare results obtained using different IC systems, Schadewaldt *et al.*[1] propose that the IC be validated, after each subject has been measured, by simulating oxygen consumption and carbon dioxide (CO_2) production with the infusion of pure nitrogen (N_2) and (CO_2) into the hose that carries the expired air mixture to the IC. From the mass flow of N_2 and CO_2 into the IC, it is possible to calculate the 'true' VO_2 and VCO_2. Any differences between the 'true' values and those measured by the IC can be corrected by application of a correction factor on each of these parameters.

An alternative post calorimetric test might be to perform an alcohol burning test, which can be used to test any IC system. Datex did suggest burning 5 ml absolute ethanol at regular intervals, using their alcohol burning test kit, to control the fixed flow rate of their Deltatrac MBM, but not after each test. However, as VO_2 and VCO_2 are recorded during the alcohol burning test, any deviations from the theoretical values (that is, calculated from the stoichiometric combustion of 5 ml absolute alcohol, which consumes 5730 ml oxygen and produces 3820 ml CO_2 with and RQ of 0.667) can be corrected and applied to the values measured during the test. The theoretical values for O_2 consumed and CO_2 produced during the combustion of 5 ml absolute ethanol, indicated above, may change slightly as a function of ethanol density at different room temperatures.

While I concur wholeheartedly with Schadewaldt *et al.*[1] that a post-test evaluation of the IC should be done after each test, one does make the assumption that the post-test evaluation is representative of the IC conditions throughout the test. This may be true of short measurements of 30 min to 1 h, but may be less so during a test of long duration of several hours, which may include a period of fasting and a post-absorptive intervention.

Whether the post-test evaluation is by infusion of N_2 and CO_2 or alcohol burning, the IC is measuring quasi steady-state values of VO_2 and VCO_2, whereas during a test, even with a ventilated hood and mixing chamber, feO_2 and $feCO_2$ fluctuate with the respiratory cycle and more so if a mouthpiece or mask are used. Although manufacturers provide information about the rapidity of the response times of their analyzers, one often has to wait several minutes to obtain stable steady-state zero and calibration values when calibrating the IC. As a consequence if the response times of the O_2 and CO_2 analyzers are not the same, there may be a tendency for the analyzer with a slower response time to measure high at low concentrations and low at high concentrations, which would not be picked up with a steady-state infusion of gases or an alcohol burning test. To simulate the effect of the respiratory cycle on measurements made by an IC it would be necessary to infuse gases with a motorized syringe. Such a system is commercially produced by Vacumed (Ventura, CA, USA), however, I have no knowledge of its use, from the literature.

Although a post-test evaluation of ICs/metabolic monitors may have some limitations, it is far better to do it than accepting the instrument's recorded values as gospel. To improve the quality of respiratory exchange data, and importantly the calculation of substrate utilization from the respiratory quotient, such a test should be included in the Standard Operating Procedure of the system and the necessary equipment to do the test should be provided by the manufacturer.

KJ Acheson
EJCN Editorial Board, Switzerland
E-mail: kjacheson@bluewin.ch

REFERENCES

1 Schadewaldt P, Nowotny B, Straßburger K, Kotzka J, Roden M. Indirect calorimetry in humans: a postcalorimetric evaluation procedure for correction of metabolic monitor variability. *Am J Clin Nutr* 2013; **97**: 763–773.
2 Vohra SB, Keegan MA, Campbell IT, McGuinness K. Practical limitations of the Deltatrac indirect calorimeter. *Clin Nutr* 1995; **14**: 155–161.
3 Cooper BG, McLean JA, Taylor R. An evaluation of the Deltatrac indirect calorimeter by gravimetric injection and alcohol burning. *Clin Phys Physiol Meas* 1991; **12**: 333–341.